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Farmers′ preferences for reductions in flood risk under monetary and non-monetary payment modes☆

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ABSTRACT

We use a split-sample choice experiment to investigate the effects of alternative payment modes on the purchase of flood insurance among smallholder irrigation farmers in Ghana. Results show that insurance up-take is lower for insurance premium payments required in labour than comparable premiums required in harvest and money. The marginal willingness-to-pay for a one-year reduction in flood frequency is about 6 h in labour time, 30 kg in rice and 144 Ghana Cedis (US $37) per annum. The price elasticities of demand for flood insurance indicate an inelastic demand for insurance premiums under these three payment modes. In addition to revealing strong preferences for flood risk reduction among farmers in this region, these results imply that subsidy policies may be inadequate in increasing the purchase of weather insurance under these three payment modes.

1. Introduction

The main purpose of the present study is to use a split-sample choice experiment to estimate and compare demand for flood insurance, sensitivities of demand for insurance to insurance premiums and willingness-to-pay (WTP) for flood risk reductions when the insurance premiums are required in three different payment modes. Specifically, the paper examines how the demand for flood risk insurance varies under monetary and non-monetary insurance premiums (i.e. labour working time and crop harvests). The paper also assesses the reactions of farmers to insurance premiums under these three modes of paying insurance premiums.

The demand for weather insurance to reduce agricultural risk has generally been low in developing countries. The coverage of agricultural risk is about 0.6% in Asia, 0.36% in Latin America and 0.1% in Africa [1]. The consequences of the low coverage of agricultural risk for human welfare are high. [2] underscore the relevance of insurance for the skewness of revenues that makes farmers less prone to downside risk. In addition, [2] present evidence to show that both crop diversification and financial insurance can be useful risk management tools. The important insight is that both crop diversification and insurance reduce downside risk and constitute important climate adaptation strategies. Further, evidence from randomized controlled trials on insurance designs indicate that innovative rainfall insurance induces farmers to shift production towards higher-return cash crops in India [3] and higher

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agricultural investments in Ghana [4]. In a recent paper, [5] review the costs of low coverage of agricultural risk; and conclude that in the absence of effective risk transfer instruments, smallholder farmers face poverty traps and subsistence consumption constraints. This contributes to difficulties in savings mobilization to cope with adverse weather shocks. Also, [6] list some of the consequences of lack of access to financial services e.g. insurance in developing countries to include risk-avoidance, risk-diversification, and adoption of informal risk-sharing measures. They find that all these measures offer inadequate risk protection and are also costly.

The expected increase in mean global temperature could expose farmers to further risks, for which weather insurance is relevant for adaptation. With the changing global climate, farmers face new risks such as biophysical risks to production systems, and higher uncertainties in farming/production decisions. The fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change [65]underscores that climate-induced hazards may exacerbate other stressors, and that these are likely to have negative outcomes for livelihoods. As a result, disaster risk preparedness and response have remained an important part of national and international measures for climate change adaptation (see e.g. Ref. [7]). Internationally, the Hyogo Framework for Action (HFA) stipulates five priority actions and outlines principles for achieving disaster resilience including disaster risk reduction in agriculture (see Ref. [8]). Furthermore, the Hyogo Framework for Action identifies the development of financial risk transfer mechanisms for building resilience for post-disaster recovery. In 2012, the African Union established African Risk Capacity to develop a pan-African index-based weather insurance and early warning systems. The African Risk Capacity combines early warning with disaster risk management and risk finance.

Several factors can cause the low demand for insurance. [5] summarize the reasons for low purchase of insurance to include problems of moral hazard, adverse selection and asymmetric information. Several innovations and designs have been developed to overcome the constraints on the purchase of insurance. These include index-based insurance schemes, flexible and better targeting of insurance programmes, and government subsidies. Under the index-based insurance as compared to traditional indemnity insurance, the payout is based on an objectively observable trigger. This is expected to reduce the insurance premiums since the verification of occurrence of shock is cheaper. [5] draw attention to the fact that most forms of moral hazard can be eliminated in index insurance. This is because farmers are unable to take actions to significantly influence the trigger index. In addition, payments of damages are based on exogenously constructed index and this leads to more efficient and timely processing and payment of claims. Despite these, [5] recommend further improvements/innovations in product design and implementation of index insurance. However, in a recent review of index insurance, [9] conclude that basis risk hampers the functioning of index-based insurance products in several countries, [9] define basis risk as a weak correlation between selected insurance index and individual loss outcomes. An important conclusion from a review of the literature on the topic indicates that index insurance is a *work-in-progress* and it is possible that redesigning and repackaging of index insurance can increase demand for insurance [10].

Many studies have identified affordability of insurance services to be one of the main reasons for the low demand for insurance (see e.g. Refs. [11–14]) for which a number of innovations and designs have been developed (see Refs. [15,16]). Affordability problems in the purchase of weather insurance can be addressed through subsidy programmes. Regarding the subsidy programmes for weather insurance, a review of subsidized programmes in Ethiopia, Ghana, India and Malawi have found that subsidies increase the demand for index insurance; especially when the demand is elastic [17]. However, government subsidization of insurance against adverse climatic changes may lead to individual decisions that increase susceptibility of people, property and economic activities to those risks [59].

An example of redesign and innovative implementation of weather insurance which is showing a great promise is requiring the insurance premiums in both monetary and non-monetary (e.g. labour time and commodities) payment modes [18]. This measure has been implemented through the Horn of Africa Risk Transfer Adaptation (HARITA); introduced in Ethiopia through the collaboration among Oxfam America, Swiss Re, International Research Institute for Climate and Society, Relief Society of Tigray and The Rockefeller Foundation [18]. The HARITA is an integrated risk management framework, which combines risk reduction, risk transfer and micro-credit. An important innovation of the HARITA programme is the “insurance-for-work” model which allows farmers to exchange labour for insurance and the labour is geared towards activities that reduce risk such as irrigation and soil conservation management [18]. [5] argue that this approach relaxes income constraints by using seasonally abundant family labour resources to invest in risk transfer and contribute to increasing the insurance up-take. It has been found that 60% of households opted for this insurance-for-work programme (see Ref. [5]). The success of HARITA has led Oxfam America to collaborate with other international programmes to expand HARITA to four countries [18].

Limited number of studies have evaluated the demand for insurance under monetary and non-monetary insurance premiums (see e.g. Refs. [14,19–21]). For instance, [20] combine monetary and labour time premiums in a choice experiment in Ethiopia to estimate subsidies for insurance adoption. Specifically, [20] find that whereas willingness-to-pay (WTP) is low relative to the yearly payout under monetary premium, the same farmers are willing to participate in working-for-insurance schemes at rates that are lower than the prevailing wage rates. The present study uses a split-sample discrete choice experiment to estimate and compare the purchase of flood insurance and price elasticities of demand for flood insurance under three alternative payment modes for paying insurance premiums; and WTP for flood risk reductions among mechanized smallholder farmers in Ghana. The split-sample design is chosen to isolate the effects of the three modes of paying the insurance premium. With the introduction of multiple prices in the preference elicitation, there is a path-dependency problem [22,23]. This means that the order in which price changes are presented to the consumer will affect the preferences elicited. Although the present paper uses the same dataset as [21]; the present paper differs in two important ways: i) whereas an integrated modelling framework is used in Ref. [21] in order to investigate relative choice uncertainties in monetary and non-monetary payment modes; the present paper presents separate model estimations for monetary, labour and harvest payment modes; and ii) these results were further used to investigate the differences in elasticities of demand for flood insurance among these payment modes. In this sense, the present paper is an applied paper. Therefore, the focus and estimation procedures of the present study are different from Ref. [21].

The main findings are that the mode of paying insurance premiums appears to affect the demand for flood risk insurance in unexpected ways. Specifically, although the three different payment modes are comparable in terms of insurance premiums when converted into the same payment modes, farmers are more likely to purchase flood insurance under monetary and harvest insurance premiums than under labour payment mode. This is contrary to common belief among insurance practitioners in developing countries. We estimate the price elasticities of demand for flood insurance to be less than 0.1% under monetary, labour and harvest payment modes. This means that increases (decreases) in insurance premiums under these three payment modes lead to less than proportionate reduction (increase) in the demand for flood insurance. Furthermore, we estimate that the marginal WTP for a one-year reduction in frequency of flooding is 6 in labour hours, 30 kg in rice and 144 GHS (≈US$37). These high WTPs indicate strong preferences for agro-climatic risk reductions among smallholder farmers in this region. The rest of the paper is structured as follows. The theoretical and econometric framework for the estimation of welfare measures under different payment modes are discussed in the next section. The third section describes the study area and the design of the discrete choice experiment (CE). The results of the study are presented in section four and the conclusions of the paper in the last section.

2. Materials and methods

2.1. Theoretical and econometric framework

The resource endowments of households differ, and these differences could be one of the avenues through which the numeraire could have implications for private and public good provision (see e.g. Refs. [24,25]). The design of insurance schemes that seek to require insurance premiums in non-monetary and monetary payment modes seek to utilize these differences in household endowments to increase the demand for weather index insurance. The use of insurance scheme designs to increase demand for insurance can work through two mechanisms. First, designing insurance schemes can make it more flexible for households to purchase insurance. Secondly, charging insurance premiums in both monetary and non-monetary payment modes can increase the purchase of insurance through the differences in household resource valuations which result from the differences in household resource endowments.

In stated preferences, the adoption of different numeraires can be a source of differences in economic decisions. One possible explanation for this is that differences in resource endowments imply constraint heterogeneity. Constraint heterogeneity refers to the non-trivial effects through which the choices of respondents depend on constraints (e.g. the use of different numeraires) for economic and environmental decisions [26]. [27] provide evidence that using monetary payment modes in stated preferences elicitation to estimate WTP values disproportionately excludes some community members. [28] show that respondents with zero monetary bids can be reversed to become positive non-monetary bids. Furthermore [29], provide evidence to show that respondents prefer non-monetary payments in exchange for environmental services. [30] argues further that the respondents with lexicographic preferences may find non-monetary exchanges such as time for environmental goods and services to be more acceptable relative to the exchange of environmental goods and services for money.

A few stated preference studies investigate mechanisms that may explain the different effects of numeraires. Examples of these stated preference studies are [20,31,32]. Using choice experiments,[31] attempt to disentangle the impact of the payment vehicle per se from the price effects in choice experiment while [32] assess the consistency and fungibility (i.e. interchangeability) of monetary valuations. Furthermore [20], examines the benefits of combining cash and labour as rainfall insurance payment modes in order to assess the extent to which subsidies may be required under both payment modes. [21] compare the uncertainties induced in choices under monetary and non-monetary payment modes in a choice experiment. [33] investigate the processing of money and time in economic transactions. According to Ref. [33] as money is the most common instrument of exchange, the use of money in transactions requires value considerations and invokes greater analytical thinking whereas time considerations in transactions are experienced or affective in nature and this is argued to affect consistency of human preferences.

Choices are constrained by multiple resources, and this makes it possible to elicit human preferences in multiple resources [34,35]. This implies that the preferences for flood risk insurance can be elicited in any economic resource provided the resource constrains the purchase of flood risk insurance [35]. Using money as numeraire, the preferences for flood risk insurance can be derived as:

$$V_m(y - WTP_m, \mathbf{p}_m, q_1; Z) = V_m(y, \mathbf{p}_m, q_0; Z) \tag{1}$$

Where $V_m(\cdot)$ is the indirect utility function; y is the income; q_0 is the status quo of no flood risk insurance; q_1 is the improved state of flood risk insurance; WTP_m is the willingness to pay for the flood risk insurance, which is elicited in monetary units; $\mathbf{p}_m$ is the vector of prices; and Z denotes socioeconomic variables. Following [35–37]; the WTP for flood risk insurance in labour units is derived as:

$$V_l(l - WTP_l, \mathbf{p}_l, q_1; Z) = V_l(l, \mathbf{p}_l, q_0; Z) \tag{2}$$

where $V_l(\cdot)$ is the indirect utility function; WTP_l is the willingness to pay for the flood risk insurance, which in this instance is elicited in labor units; l is the full budget stated in labour units; $\mathbf{p}_l$ is the vector of full prices in labour units; and other notations as stated earlier. Furthermore, we can infer from Refs. [28,38] that WTP for flood risk insurance elicited in rice is given as:

$$V_r(r - WTP_r, \mathbf{p}_r, q_1; Z) = V_r(r, \mathbf{p}_r, q_0; Z) \tag{3}$$

where $V_r(\cdot)$ is the indirect utility function; WTP_r is the willingness to pay for the flood risk insurance, which is elicited in rice yield; r is the full budget stated in rice yield; $\mathbf{p}_r$ is the vector of full prices in rice yield; and other notations as stated earlier.

To elicit preferences for attributes of flood risk reduction, we used choice experiment (CE), which is one of the stated preference methods. The CE is based on a new consumer theory [60] which postulates that utility is derived from attributes rather than goods themselves. In CEs, respondents face a number of choice tasks. The choice set consists of at least two alternatives, which are defined by attributes and attribute levels. The respondents then choose their preferred alternative in each choice task. The choices in CE are hypothetical in nature, however, [39] show that economic incentives are preserved in these hypothetical choices. Following analyses of demand for flood risk insurance in Vietnam in Ref. [14]; we adopt random-parameter error component specification of the utility function for flood risk insurance. The random-parameter error components model allows for inter-alternative correlation between alternatives. According to Ref. [40]; the random parameter model can theoretically approximate any random utility model (RUM). The random-parameter specification of error components model allows the utility function to combine both the random parameter and error component and this resolves independence of irrelevant alternative (IIA) and addresses unobserved heterogeneity [41]. The purchase of insurance provides changes in the utility that could be different from the status of not buying the insurance.

We specify the utility structure for the random-parameter error component model by:

$$U_{njt} = \alpha_n x_{njt} + \varepsilon_n + u_{njt} \tag{4}$$

where U_{njt} refers to utility a farmer, n, derives from alternative j on choice occasion t , α refers to the parameters (i.e. means and standard deviations) corresponding to different insurance attributes, x, u are the unobserved utility components which are assumed to be independently and identically type I extreme value distributed (Gumbel). The error component, ε, is distributed $N(0, \sigma^2)$. Further, we define $\alpha_n = \mu + \sigma\eta_n$, where η_n is the random idiosyncratic shock and μ and σ are the population mean and standard deviation respectively. Specifying the error components for all alternatives in the choice set leads to over-identification of the model. Therefore, we normalize the variance component of the status quo alternative to zero [42,43]. The idea is that respondents are familiar with the status quo alternative of no flood insurance and are therefore prone to less error.

With a panel of T discrete choices for each respondent n, we can follow [21,43] to specify the joint probability of sequence of these choices $\{y_1, y_2, y_3, ..., y_T\}$ by an individual as:

$$P(y_1, y_2, ..., y_T) = \int_\alpha \int_\varepsilon \prod_{t=1}^{T} \frac{\exp(\alpha x_{njt} + \varepsilon_j)}{\sum_{i=1,2,3} \exp(\alpha x_{nit} + \varepsilon_i)} \phi(\varepsilon|\sigma^2) f(\alpha|\theta) d\varepsilon d\alpha \tag{5}$$

Note that the integral from equation (5) does not have a closed form. However, it can be simulated by averaging over a number of draws from an assumed distribution[61]. In our case, we approximate the simulated log-likelihood function by numerical simulation using 1000 Halton draws for monetary and labour payment modes and Modified Latin Hypercube Sampling (MLHS) approach (see Ref. [44]) for the harvest payment mode. We assume normal distributions for all random attributes. These draws and distributions were retained because they were found to provide better model fits in the preliminary model estimations.

2.2. *Study area and the design of choice experiments*

Irrigation is usually seen as a strategy for reducing poverty and improving food security in the developing countries [16,45,46]. Only 4% of total land in Sub-Saharan Africa is irrigated [16] and the existing irrigation infrastructure is poorly maintained. As a result, prolonged rainfalls can easily cause a flood and damage crops and property. The present study was conducted at Wheta/Afife Irrigation Scheme (WIS) located within the Volta River Basin in Ghana. Together with Dawhenya Irrigation Scheme and Asutsuare Irrigation Scheme, WIS is one of the main rice growing schemes in Ghana [47]. The initial dam was constructed in the 1960s and the capacity was expanded by the construction of the second dam in the 1980s to irrigate rice fields. It has potential for about 950 ha, but 880 ha was developed and irrigated (see Refs. [48,49]). Currently, the Ghana Irrigation Development Authority manages all irrigation schemes including WIS.

Devolution is a common mandate for managing common-pool resources. Under devolution, resource users are required to make monetary and non-monetary sacrifices to support participatory resource management. Devolution has remained an integral part of agricultural policy in Ghana since the structural adjustment programme implemented since the early 1980s [63]. Currently, farmers at WIS adopt different measures to mobilize resources for maintaining irrigation infrastructure including mobilization of monetary and non-monetary resources. In addition, the canals have not been properly maintained as many of the canals are silted. Floods destroy crops regularly (see the next section). Labour is a costly factor of production [50] as it takes a significant component of cost of production. As a result, the farming system at WIS is highly mechanized in that farmers adopt labour-saving technologies such as tractors and harvesters to reduce the production cost.

Data is not readily available for the estimation of demand for flood risk insurance (see Ref. [51]). We, therefore, elicited preferences for reductions in flood risk using hypothetical choices of farmers in a choice experiment on the purchase of flood insurance. Preliminary surveys for the choice experiment were conducted in July 2015 during which focus group discussions were held among farmers; additional discussions were held with the management of the WIS on agro-climatic shocks to irrigation farming in the case study area. During the focus group discussions, farmers perceived flood risk to be a greater threat than drought risk as the construction of dam for irrigation reduced the impact of drought on rice production in the area. The scenario was changed from drought to flood and the pilot study and the main data collection were conducted from November 2015 to February 2016.

The survey was conducted in face-to-face interviews, since other survey administration modes (e.g. phone, internet and mail, etc.) were not possible (see Ref. [52]). The respondents were recruited randomly from communities surrounding WIS and during field visits.

For each of the main communities surrounding WIS, we divided the community into four and sampled identified respondents from these parts for interview. Some of the main communities covered include Avalavi, Klenormadi, Kpeyiborkope, Wheta, Dekpor and Laveh. During the field visits, we also identified farmers from randomly selected blocks from each of the eleven sections at WIS. In all, we interviewed 398 irrigation farmers: 132, 133 and 133 respondents were interviewed with the labour, rice and monetary payment modes, respectively. Each respondent made 12 hypothetical choices and the respondents were assigned to each of the three payment modes. Efficient designs with zero priors were used for the pilot survey. Parameter estimates using the results from the pilot survey were used as priors to generate an efficient design for the multinomial logit model (MNL) model in the main survey and this is deemed enough for the estimation of panel mixed logit model (see Ref. [53]). The design was created using Ngene [54]. The attributes and the attributes levels are presented in Table 1. Five attributes were used for each of the modes for the payment of the insurance premium. The selection of attributes was based on focus group discussions among the farmers and from the existing literature particularly [14]. The attributes are:

a) ***Flood occurrence*** - this refers to the number of years it will take for a flood incidence to recur. This attribute measures different degrees of flood frequency in the choice experiment. The attribute levels for flood occurrence are 6, 8 and 10 years. The selection of attribute levels for flood occurrence was informed by observations of [28] that the flood return period is between five to ten years in flood prone areas in Bangladesh. The descriptive statistic presented in section 3.1 below shows that the farmers suffer a flood approximately every two years at Wheta Irrigation Scheme. This shows clearly that the actual flood occurrence is more severe than what was presented in the choice experiment. It must be noted that some of the flooding episodes that farmers perceive may not be severe enough to warrant insurance payout. Nevertheless, the disparity between this attribute and perceptions of farmers may lead to hypothetical bias. With the extensive pilot testing, we believe this effect may be minimal.
b) ***Insurance coverage*** – this is the number of 50 kg bags of rice that the insurance company will pay in compensation if a flood occurs. Contrary to Refs. [14,19,20]; we framed this attribute as non-monetary compensation. The choice of output compensation instead of monetary compensation is informed by evaluations of payment for ecosystem schemes that in-kind transactions are more preferable to farmers (see e.g. [66]). The implications of this for preferences for flood risk reductions may be negative given the reduced fungibility of in-kind compensation. The average output among the farmers were assessed to be about 20 bags of rice and additional attribute levels were selected around the average output. The insurance coverage has three levels of 12 bags, 21 bags and 30 bags.
c) ***Probability of damage*** – this refers to the probability that the farmer is affected by the flood; and this is presented as an approximate number of farmers affected by a flood out of every 6 farmers. The three levels identified are two (2) in about every 6 farmers, three (3) in about every 6 farmers and four (4) in about every 6 farmers. These levels were informed by discussions with extension officers that reveal that 5 out of the 11 sections are flood prone. We constructed attribute levels based on this information. We deliberately opt for an objective measure for this attribute as compared to subjective probability measures (see e.g. Ref. [55] to ensure that farmers are responding to comparable levels for this attribute.
d) ***Insurance premium*** – this refers to the cost of purchasing the flood risk insurance per ha. As noted above, the insurance premium was stated in money (i.e. Ghana Cedis, GHS), rice (i.e. number of 50 kg bags) and in labour time (i.e. working hours). Prior to the main survey, we conducted a quick survey among farmers to determine the price of rice and wage compensations paid to hired labour. The results from this survey were used to determine exchange rates among the three modes for paying insurance premium. Secondly, we decided on an average premium rate of 20%, and this is deliberately chosen to be higher than subsidized index premium rates in developing countries (see Ref. [6]). Additional attribute levels were constructed around this average premium rate. Each of these modes of insurance premium has three identical levels of 150 GHS[1] (≈15 h ≈2 (50 kg) bags of rice), 300 GHS (≈30 h ≈4 (50 kg) bags of rice) and 450 GHS (≈45 h ≈6 (50 kg) bags of rice) per ha. The market exchange rates were used in the conversion, and the exchanges rates, were pretested in the pilot surveys as well.

Farmers are likely to have different plot sizes, and this may affect the purchase of insurance in the CE. As such, we introduce plot size as an additional attribute to fix the context for the purchase of flood insurance. The plot size also has three levels of 1, 2, and 3 ha. The choice cards presented in Figs. 1–3 below show how the plot size attribute was used to hold the context of the choice experiment constant.

An increase in risk exposure (i.e. a fall in flood occurrence and an increase in the probability of incurring damage) is expected to lead to an increase in the demand for insurance. Furthermore, it is expected that higher coverages will increase the purchase of insurance whilst premium, in all its forms, will have negative effect on the demand for insurance. Finally, we expect that for farmers that are more likely to be risk-averse, the coefficient for plot size should be negative. A sample of the choice cards shown in each of the modes for paying insurance premium are presented in Figs. 1–3.

3. Results

We present the analyses of the results from the survey in this section. We begin the analyses of the results by first discussing the

[1] The exchange rate was 1 GHS = 0.26 US dollars at the time we collected the data. The price level ratio of PPP conversion factor (GDP) to market exchange rate in 2015 was 0.33 (World Bank, http://data.worldbank.org/indicator/PA.NUS.PPPC.RF?end=2015&start=2014). This means that one requires 0.33 US dollars to buy one US dollar worth of goods in Ghana.

Table 1
Attributes and attributes levels.

Attribute	Flood occurrence	Probability of damage	Coverage (per ha)	Monetary premium (GHS)	Labour premium (Hours)	Rice premium (50 kg bag)
Level 1	Once in every 6 years	2 in every 6 farmers	12 (50 kg) bags	150	15	2
Level 2	Once in every 8 years	3 in every 6 farmers	21 (50 kg) bags	300	30	4
Level 3	Once in every 10 years	4 in every 6 farmers	30 (50 kg) bags	450	45	6

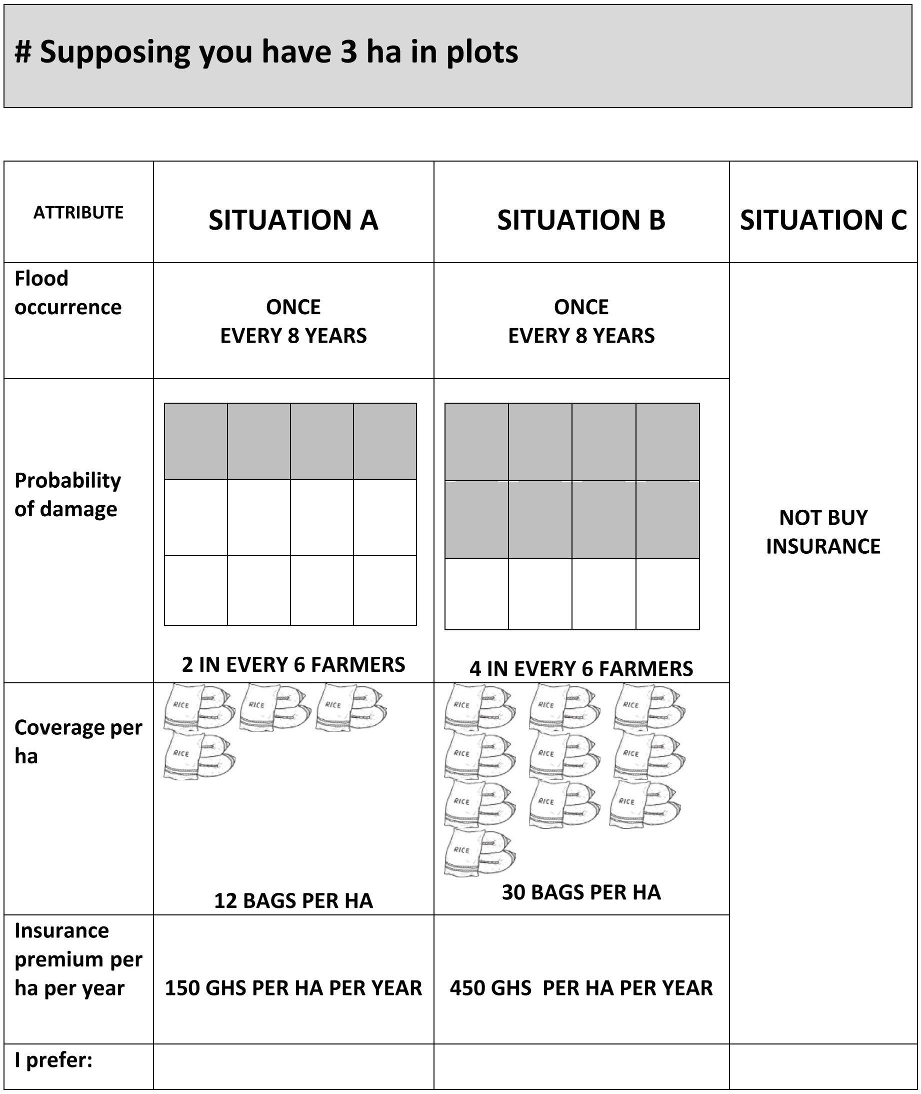

Fig. 1. A sample of choice card with monetary insurance premium.

descriptive statistics of the sample. This is followed by the presentation and discussion of the estimated results, and the willingness to pay and elasticity estimates under the three modes of insurance premium.

3.1. Descriptive statistics

The descriptive statistics of the three sub-samples are presented in Table 2. In this table, we use Kruskal-Wallis test to perform statistical test on whether the descriptive statistics are significantly different among the three sub-samples. The socio-economic characteristics of the sample indicate that about 34% of the respondents are female and this does not differ among the three sub-samples. The average age of the sample is about 48 years. On average, farmers have been farming for about 25 years. The means

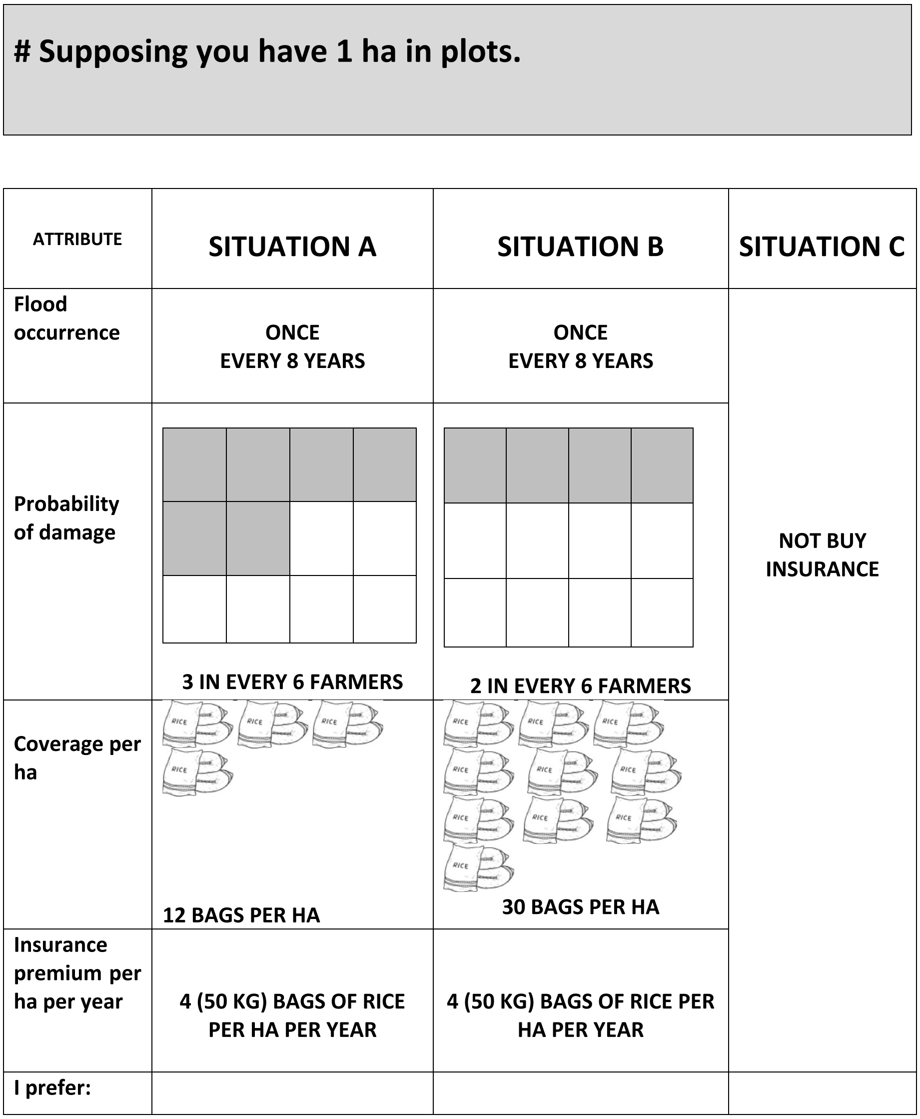

Fig. 2. A sample of choice card with rice insurance premium.

of age and years of farming experience do not differ among the three sub-samples. In addition, low proportions of farmers (about 17%) indicate secondary school education and above and this remains the same across the three sub-samples. In total, each farmer has on average about 4 ha in rice farming and the means of plot size differ statistically among the three sub-samples. For the whole sample, the average output is about 1 metric ton (MT) per ha.

The incidence of a flood is perceived to be high among farmers. On a 1 to 6 scale, with 1 indicating “not important all” and 6 indicating “very important”, the average Likert score is 5.37. The means of Likert score on perceptions of flood incidence differ among the three sub-samples. Flooding appears more destructive to the farmers relative to other natural disasters. This is because the mean score of incidences of other natural disasters is lower than that of flooding. It must also be noted that perceptions on the incidence of flooding and other natural disasters differ among the three sub-samples. However, the perceptions on the incidence of a flood damage over the past ten years do not differ among the three sub-samples. Although the perceptions on the incidence of a flood damage remain high, it is lower than the overall perceptions on flood incidence in general. Furthermore, perceptions on increasing flood trends and durations are high. That is, more than 70% of the total sample perceive both a flood trend and duration to be increasing and these perceptions do not differ among the three sub-samples.

On average, farmers experience floods every other year. This is because more than 75% of the farmers interviewed experience flood damage within the previous two years of the survey and this remains the same among the three sub-samples. The majority of farmers experience their most recent flood in the year 2015. However, the highest number of farmers recorded the severest flood in the year 2006. Furthermore, the farmers think that a flood is likely to recur within the next five years. In addition, the chances of a flood affecting the farmers within the next five years is high.

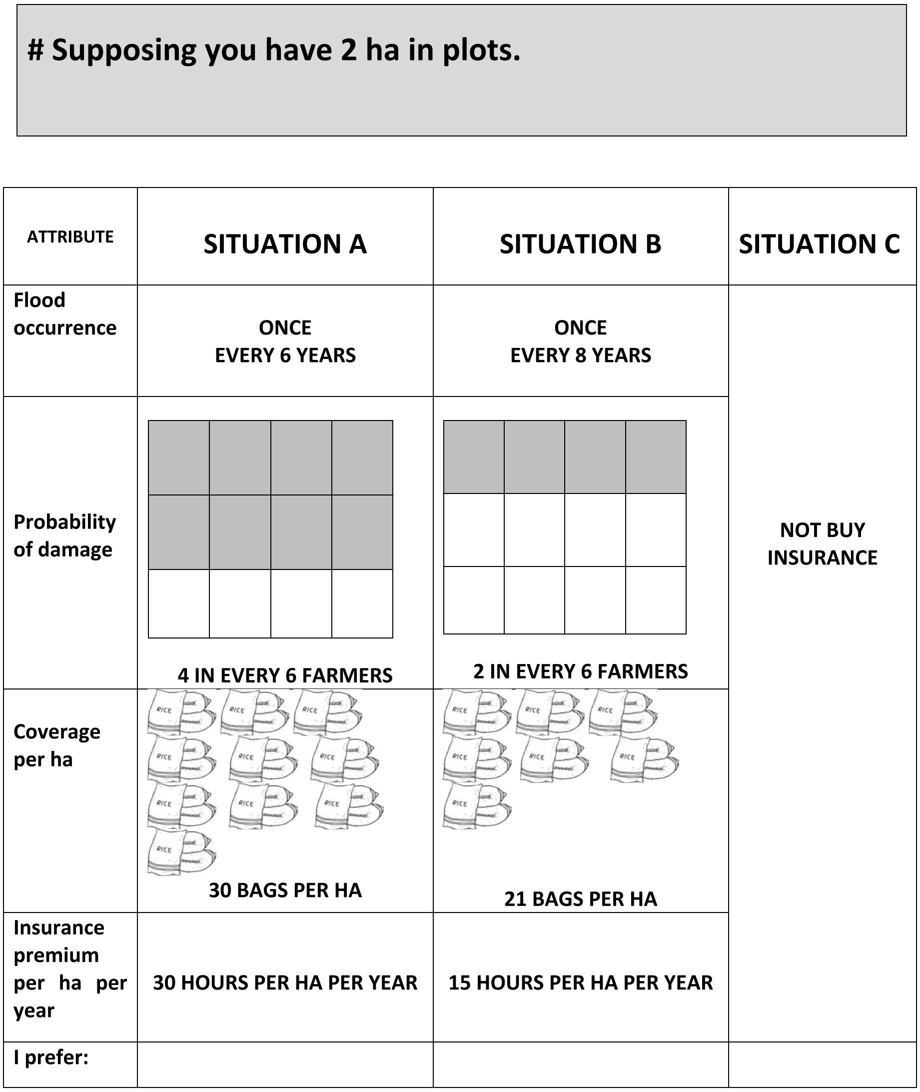

Fig. 3. A sample of choice card with labour insurance premium.

Credit constraints seem severe as can be seen from the high score reported for lack of credit opportunities in Table 2. Similarly, poor infrastructure is a common problem in the communities in which the farmers live. The perceptions on the availability of credit and infrastructure do not differ among the three sub-samples. These may be indications of severe market imperfections among the communities surrounding the WIS. Apart from output per ha and plot size, farmers interviewed under the three insurance payment options are identical.

The chosen alternatives appear to be distributed quite equally among the three alternatives. Three alternatives were presented to the farmers in the choice experiment; and these are one status quo (SQ) alternative of no insurance and two alternatives that indicate the purchase of insurance. Statistically, the proportions of respondents who chose the SQ alternative differ among the three subsamples. This proportion is 33% for labour payment mode but 31% and 29% for harvest and monetary payment modes respectively. Clearly, this percentage is higher under labour payment mode than under the remaining two payment modes. This means that the decisions not to purchase insurance are more likely under labour payment mode. Similarly, the percentage of respondents who purchased flood insurance is lower under labour payment mode than monetary and harvest payment modes. In most CV studies that compare monetary versus non-monetary payments, the probability of accepting the scenario is higher under the non-monetary payments than under the monetary payments (see e.g. Ref. [36]). One plausible explanation could be the avoidance of 'yea-saying' problem in choice experiments (see e.g. Ref. [56]). We also checked and found that the respondents respond to high insurance premiums by reducing the purchase of insurance (i.e. choose the status quo of not buying the flood insurance) under the three payment modes, when the cost of the insurance premiums are high. This was the case in the fourth and eighth choice occasions as shown in Fig. 4 below. Specifically, the purchase of insurance decreases during the fourth and eighth choice occasions and these occasions correspond to an increase in the proportions of respondents who chose the SQ alternative.

Table 2
Descriptive statistics of the sample and choices for the three subsamples.

Variables with descriptions	Labour time		Rice yield		Monetary		Whole sample		Kruskal-wallis test		
	Mean	S. E.	Mean	S. E.	Mean	S. E.	Mean	S. E.	CHI-square		P-value
Share of female farmers	0.31	0.04	0.36	0.04	0.34	0.05	0.34	0.02	0.38		0.83
Age (in years)	49.40	1.42	48.01	1.15	47.86	1.15	48.43	0.72	0.77		0.68
Farmers with at least secondary education (%)	16.70	3.26	19.50	3.45	13.50	2.98	16.60	1.87	0.72		0.70
Household size	7.07	0.35	6.73	0.30	6.56	0.31	6.78	0.19	1.57		0.46
Number of years in farming	25.13	1.19	25.00	1.06	24.04	1.06	24.74	0.64	0.12		0.94
Output per ha in main farming season (metric ton)	0.96	0.04	1.06	0.05	0.89	0.05	0.97	0.03	8.65	**	0.01
Plot size (in ha)	4.74	0.36	3.56	0.38	3.32	0.23	3.87	0.19	15.94	***	0.00
Poor infrastructure[a]	5.95	0.02	5.91	0.03	5.92	0.04	5.92	0.02	0.05		0.98
Lack of credit opportunities[a]	5.89	0.03	5.86	0.04	5.91	0.03	5.89	0.02	0.21		0.90
High incidence of flood[a]	5.06	0.13	5.71	0.05	5.35	0.12	5.37	0.06	9.85	***	0.01
Incidence of other natural disasters[a]	4.24	0.15	3.91	0.13	4.16	0.14	4.10	0.08	5.25	*	0.07
Incidence of flood for past 10 years	5.33	0.37	4.85	0.31	5.81	0.37	5.32	0.20	4.42		0.11
Last flood occurred within last two years (= 1 if yes)	0.74	0.04	0.77	0.04	0.74	0.04	0.75	0.02	0.26		0.88
Perceptions that flood trend is increasing (%)	65.91	4.14	72.73	3.89	74.81	3.81	71.14	2.28	2.13		0.34
Perceptions that flood durations are increasing (%)	64.12	4.21	74.24	3.82	74.05	3.84	70.81	2.29	3.30		0.19
Risk of flood occurring within 5 years[a]	4.82	0.14	5.38	0.11	4.86	0.14	5.02	0.08	10.74	***	0.00
Chance of flood affecting the farmer[a]	4.26	0.17	4.83	0.16	4.38	0.18	4.49	0.10	9.50	***	0.01
Proportions of SQ choices	0.33	0.01	0.31	0.01	0.29	0.01	0.31	0.01	11.79	***	0.00
Proportions of insurance purchase choices	0.67	0.01	0.69	0.01	0.71	0.01	0.69	0.01	11.79	***	0.00

*** Significantly different at 1% level; ** significantly different at 5% level; * significantly different at 10% level.
Note that the superscript a means that the variable was measured on a 1–6 Likert scale with 1 = "lowest" and 6 = "highest".

3.2. Main estimation results

We estimate the random-parameter error components models for the three insurance payments. First, given the objective nature of the probability attribute, we interact this attribute with various subjective measures; and especially those regarding the occurrence of floods that are significantly different among the three sub-samples. All these interactions terms are not statistically significant, and were not included in the final estimations. However, two interactions with the alternative specific constants (ASCs) were retained in the estimations. All models were estimated in preference space. The models were estimated using R based on [64]. The results from the

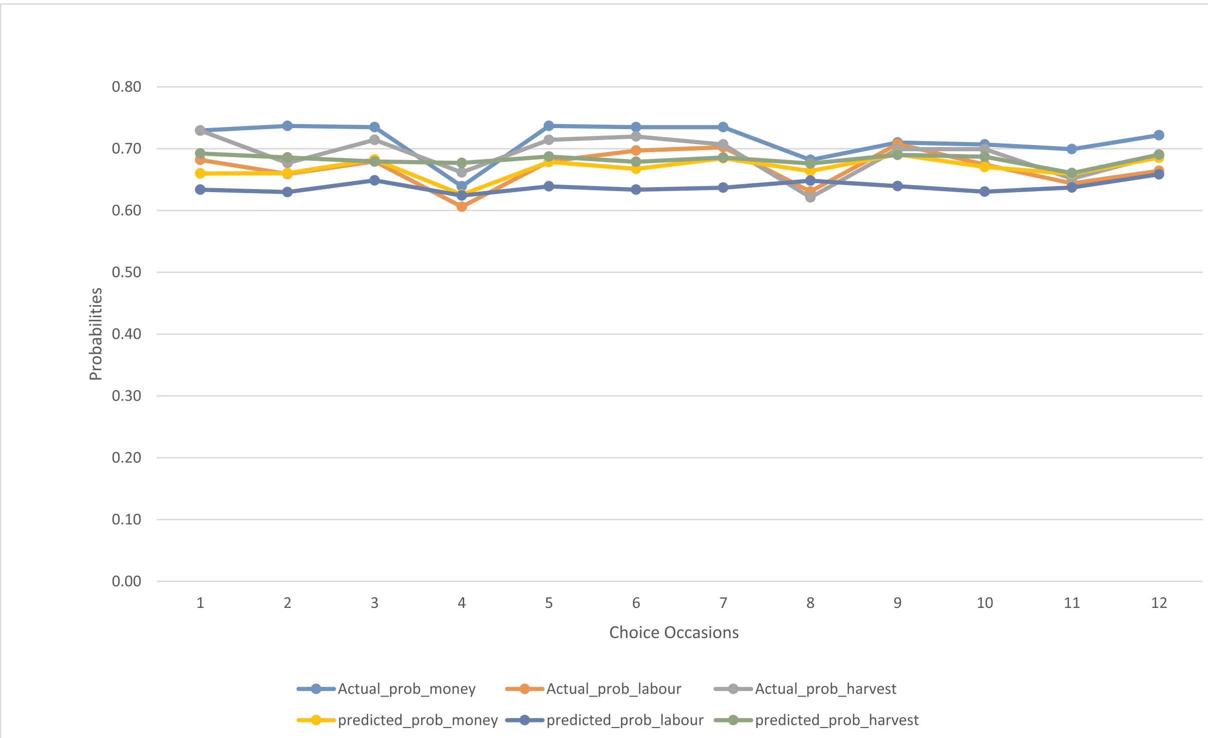

Fig. 4. Actual and predicted probabilities for purchasing flood insurance under the three payment modes.

maximum likelihood random-parameter error components models are presented in Table 3.

The actual parameter estimates from the three models cannot be compared because the parameter estimates are confounded by scale parameters. Using the same dataset in an integrated estimation framework, [21] find the relative scale parameters for non-monetary payment modes to be lower than the relative scale parameter for monetary payment mode. This underscores that the parameter estimates presented in Table 3 cannot directly be compared. It is important to point out that the signs of the coefficients associated with the standard deviations are irrelevant and are mostly interpreted as positive irrespective of the signs. The first column of results presented in Table 3 are the results for the subsample for which the insurance premium was in monetary payment mode. These results indicate that the means for flood occurrence, coverage, insurance premium and plot size are statistically significant. If the flood occurrence increases, i.e. it takes longer for floods to recur, the purchase of flood insurance falls. The higher the coverage/compensation, the higher the purchase of flood insurance. When the premium increases, the purchase of flood insurance falls. Furthermore, when the plot size increases, the purchase of flood insurance falls. The standard deviations for plot size, probability and flood occurrence are also statistically significant. This means that there is heterogeneity in preferences for these attributes. The ASC is not statistically significant. Both error components are statistically insignificant. Only one of the two interaction terms with ASC is statistically significant; and this result indicates that when risk perceptions among farmers are high, they are less likely to choose the status quo of not purchasing flood insurance.

The second column of Table 3 presents the results for the sub-sample of respondents who were interviewed with the version of the survey in which the insurance premium was required in labour time. The means of flood occurrence, insurance premium and plot size are statistically significant. This means that as the number of years it takes flood incidence to recur, the purchase of flood insurance falls. Similarly, as the insurance premium increases, the purchase of flood risk insurance falls. Also, if the plot size increases, the purchase of flood insurance decreases. This means that farmers with bigger plot sizes are less likely to purchase flood insurance. In addition, the standard deviations of flood occurrence and plot size are statistically significant indicating heterogeneous preferences for flood occurrence and plot size under the labour payment option. The ASC and the two error components are not statistically significant. Only one of the two interaction terms with ASC are statistically significant and this means that farmers who think that they are more likely to be affected by flooding are less likely to choose the status quo alternative.

The last column of Table 3 presents the results for the sub-sample of respondents who answered the survey in which the insurance premium was required in rice harvest. From the results of this model, the means of flood occurrence and the insurance premium are statistically significant. It means that if the number of years it takes for a flood to recur increases, the purchase of flood risk insurance is likely to decrease. Similarly, when the insurance premium increases, the demand for flood insurance is likely to decrease. In addition to the statistical significance of these means, the standard deviations of plot size and probability are statistically significant. This means that there is heterogeneity in preferences for plot size and probability under the rice insurance premium. The ASC and its two interaction terms together with the error components are not statistically significant.

All the ASCs are not statistically significant. This implies that the respondents are not reluctant to choose the SQ of not purchasing the flood risk insurance. The probability of farmer being affected is not statistically significant under all the three modes of paying insurance premiums. This could be attributed to problems in processing the probability attribute among the sample especially given the low percentage of the respondents receive above primary education. The statistical insignificance of the probability attribute may also be due to the high attribute levels for the probability attribute. Therefore, better risk communication devices need to be considered in future choice experiments. It should be recalled that the plot size attribute was introduced to define the context for the choices being made. The three model specifications perform quite well as indicated by the model characteristics presented in Table 3. For instance, the adjusted rho squared are between 0.41 and 0.45 for the three models.

Given that the parameter estimates reported in Table 3 cannot be compared, we use the results to predict the probabilities of purchasing flood insurance for each choice occasion for all the respondents. Unlike the parameter estimates, these probabilities can be compared across the three payment modes. We plot the actual and predicted probabilities for purchasing flood insurance for each of the 12 choice occasions in Fig. 4.

One can see from Fig. 4 that both the actual and predicted probabilities are close together for all the 12 choice occasions.

3.3. Willingness-to-pay and elasticities of demand for flood insurance

The results from Table 3 were further used to estimate welfare estimates in the form of marginal WTPs and elasticities of demand for flood insurance; which are presented and discussed in this sub-section. It is important to note that marginal WTPs and elasticities can be compared. During the derivations of marginal WTPs, the scale parameters cancel out and for this reason the marginal WTPs can be compared especially when they are converted into the same currency units. Similarly, since elasticities of demand for flood insurance indicate percentage changes in insurance purchase as a result of 1% changes in premiums, the elasticities of demand can also be compared. Since the purpose of introducing plot size among the list of attributes is to hold the context for the decisions in the choice experiments fixed, we did not derive the marginal willingness to pay for the plot size. The marginal WTPs for flood occurrence are computed using the procedure of [57]. The marginal WTPs were simulated with 10,000 draws using the means and standard deviations. These marginal WTPs are statistically significant at the 1% level for the three payment modes. Under the labour payment mode, the marginal WTP per farmer for flood occurrence is 5.74 h in labour time per annum. This means that, on average, the farmers are willing to contribute about 5.74 h for a one-year decrease in flooding frequency. Based on the exchange rate used in the choice exchange, the marginal WTP of 5.74 h is equivalent to 57.40 Ghana Cedis, and 38.27 kg of rice. Under the harvest payment mode, the marginal WTP is 29.93 kg of rice per annum. This means that, on average, the farmers are willing to contribute about 30 kg of rice yield for a one-year decrease in flooding frequency. Using the pre-determined exchange rate used in designing the choice experiments, we

Table 3
Results of random-parameter error components models.

	Money		Labour		Rice	
Alternative specific constant (asc)	−0.929		−0.401		−1.333	
	1.203		1.325		1.488	
Interactions between asc and risk	−4.160	***	−0.586		−0.921	
	0.956		1.122		1.096	
Interactions between asc and affect	−1.683		−3.125	**	−1.188	
	1.255		1.155		1.064	
Plot size (mean)	−1.241	**	−1.885	**	−2.514	
	0.610		0.795		1.353	
Plot size (standard deviation)	−3.334	**	6.358	***	−4.989	**
	1.329		2.081		2.066	
Flood occurrence (mean)	−0.399	***	−0.148	***	−0.132	***
	0.059		0.035		0.042	
Flood occurrence (stan. deviation)	−0.275	***	−0.095	**	−0.197	***
	0.032		0.036		0.033	
Coverage (mean)	0.036	***	0.006		−0.004	
	0.011		0.010		0.010	
Coverage (stan. deviation)	0.000		−0.010		−0.027	
	0.014		0.012		0.020	
Probability (mean)	−0.050		−0.071		−0.079	
	0.056		0.052		0.052	
Probability (stan. deviation)	0.155	**	0.005		0.124	
	0.055		0.028		0.071	
Insurance premium (mean)	−0.277	***	−0.257	***	−0.004	***
	0.070		0.068		0.001	
sig 1	0.007		−0.047		−0.358	
	0.057		0.069		0.212	
sig 2	−0.083		0.063		−0.296	
	0.110		0.118		0.172	
sig 3 (fixed)	0.000		0.000		0.000	
	NA		NA		NA	
Model diagnostics						
LL (final)	−966.707		−935.100		−1004.920	
LL (0)	−1746.794		−1731.413		−1748.991	
Adjusted rho squared	0.440		0.450		0.410	
AIC/n	1.241		1.212		1.288	
BIC/n	1.309		1.280		1.355	
n (observations)	1590		1576		1592	
r (respondents)	133		132		133	
k (parameters)	20		20		20	

NB: *** indicates statistical significance at 1% level; ** indicates statistical significance at 5% level; and * indicates statistical significance at 10% level. Robust standard errors are in the parentheses.

compute that the marginal WTP of 29.93 kg of rice is equivalent to 44.90 Ghana Cedis and 4.50 h in labour time. Finally, under the monetary payment mode, the marginal WTP is 144.07 GHS (US$37.46) per annum. This means that farmers are willing to pay, on average, US$37.46 for a one-year reduction in flooding frequency. If one uses the exchange adopted in designing the choice experiment, the marginal WTP of 144.07 GHS is equivalent to 14.41 h in labour time and 96 kg of rice. Although the insurance premiums under the three payment modes are comparable, we can see that the values of marginal WTPs differ depending on the payment modes used in the computation of the welfare measures. These high WTP values underscore the relevance of environmental risks among the smallholder farmers.

In addition to marginal WTPs, we use the results to estimate the price elasticities of demand for flood insurance. The estimated price elasticities of flood insurance are −0.061, −0.062 and −0.062% for the monetary, labour and harvest payment modes; respectively. These results indicate an inelastic demand for flood insurance under all three payment modes. Specifically, when the insurance premiums increase by 1%, the demand for flood insurance falls by less than 0.1% for all the three payment modes. The magnitudes of these elasticity estimates appear to be lower than the elasticity figures reviewed in Ref. [10], which were found to be in the range of −0.44 and −0.88 for China and India. Nevertheless, these figures from China and India also indicate an inelastic demand for weather insurance. The evidence presented in this study also suggests that economic transactions especially pertaining to the decisions on the purchase of flood insurance under monetary as well as *in-kind* payment modes are largely determined by the same considerations. This is because the parameter estimates have the same signs and statistical significance under three modes of paying for flood insurance.

4. Conclusions

With a view to increasing the up-take of insurance for agro-climatic risk transfer, an increasing number of insurance practitioners seek to relax the affordability restrictions on the purchase of weather insurance by redesigning insurance schemes and innovative implementation of these schemes. One of these designs that show great promise is requesting insurance premiums in non-monetary payments, such as labour time in order to increase the purchase of insurance for agro-climatic risks and human health risks. In this paper, we use a split-sample discrete choice experiment to estimate the preferences of farmers for flood risk reductions in labour time, rice harvest and money insurance premiums. Contrary to widespread belief among practitioners, farmers are more likely to purchase flood insurance under monetary and harvest payment modes than under labour payment mode. Therefore, we do not find support for claims that requesting insurance premiums in labour will substantially increase the purchase of insurance.

We find that, on average, farmers are willing to contribute about 5.74 h in labour time payments, about 30 kg in rice harvest payments and 144 GHS (approx. US$37) per annum for a one-year decrease in flood frequency. These WTP estimates largely reflect the relevance of flood risk reduction measures among small-scale farmers. Therefore, flood risk management measures are required in order to reduce the vulnerability of farmers. We estimate price elasticities of demand for flood insurance to be price inelastic under the three payment modes for the payment of insurance premiums. The policy implications of this finding are that not only is the degree of sensitivity of the purchase of weather insurance similar under the three payment modes, but also subsidies are a costly way of increasing the purchase of insurance as the magnitudes of subsidy required will be prohibitively high. We also found that welfare estimates vary across payment modes. Thus, there is a need for future choice experiments to investigate reasons for these differences in welfare measures. In addition, future studies may want to quantify welfare implications of adopting monetary and *in-kind* insurance premiums in empirical studies.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wre.2019.100151.

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